GAU 3611
#7

ATI-188

UNITED STATES PATENT AND TRADEMARK OFFICE

Examiner: P. English   Art Unit: 3611

Re: Application of: David S. Breed et al.

Serial No.: 09/084,641

Filed: May 26, 1998

For: METHOD AND APPARATUS FOR DETECTING THE PRESENCE OF A CHILD SEAT

SUBMISSION OF DECLARATION UNDER 37 C.F.R. 1.131

Assistant Commissioner for Patents
Washington, D.C. 20231

November 5, 1998

Dear Sir:

With reference to the amendment filed October 16, 1998, submitted herewith is signed Declaration Under 37 C.F.R.1.131 for the above-referenced application.

An early and favorable action on the merits is earnestly solicited.

FOR THE APPLICANTS
Respectfully submitted,

Brian Roffe
Reg. No. 35,336

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Enclosures
Declaration Under 37 C.F.R. Section 1.131

I hereby certify that this correspondence and/or fee is being deposited with the United States Postal Service as first class mail in an envelope addressed to "Assistant Commissioner for Patents, Washington, D.C. 20231" on NOVEMBER 5, 1998.

Brian Roffe, Esq.

ATI-188

UNITED STATES PATENT AND TRADEMARK OFFICE

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In re Application of:	David S. Breed et al.
For:	METHOD AND APPARATUS FOR DETECTING THE PRESENCE OF A CHILD SEAT
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DECLARATION UNDER 37 C.F.R. 1.131

Hon. Commissioner of Patents and Trademarks
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

David S. Breed, Wendell C. Johnson and Wilbur E. DuVall, the inventors in the above-identified application, declare as follows:

1. Prior to April 12, 1994, while working together in the U.S., we conceived of a vehicle interior monitoring system (VIMS) in which a system in a vehicle is controlled based on the recognition and identification of an occupying item in the vehicle's passenger compartment as set forth in the claims pending in this application. This conception occurred in the U.S. In conjunction with the identification of the occupying item, a child seat and occupant position detector (CSOPD) was also conceived.

2. Based on our invention, David S. Breed and Wilbur E. DuVall prepared in the U.S., with the assistance of Vittorio Castelli, a paper for presentation at the Society of Automotive Engineers (SAE) annual conference which took place in Detroit, Michigan, U.S.A. on February 28 to March 3, 1994. This paper was assigned SAE Paper No. 940527 and is attached hereto.

3. As set forth on page 1, first column, second paragraph, the VIMS is designed to enhance the operation of automotive systems, such as the heating, air conditioning and entertainment systems, to adjust the operation of these systems in accordance with the occupancy of the vehicle.

4. As set forth in the section bridging pages 3 and 4, the CSOPD is designed to detect the presence of a child seat, as opposed to, e.g., an adult occupant.

5. One of the most important systems which can be controlled by the recognition and identification elements is airbag deployment, i.e., the airbag can be disabled if the occupying item of the vehicle is a child in a rear facing child seat or in the absence of an occupant (see page 2, second column).

6. The airbag deployment can be controlled entirely based on the recognition and identification of the occupying item, i.e., when the occupying item is a rear facing child seat, without even determining the position of the occupant. This is because airbag deployment should be disabled whenever there is a rear facing child seat in the seat to be affected by airbag deployment, regardless of the position of the rear facing child seat (see page 2, second column).

7. To this end, a "pattern" from different occupying items is obtained, e.g., a rear facing child seat, an adult occupant, a forward facing child seat, a box, a bag of groceries, and stored in a pattern recognition apparatus, these patterns being different from one another.

8. Thereafter, in operation, different sensors are used to obtain a pattern from the occupying item, e.g., ultrasonic sensors that receive ultrasonic radiation radiated into the passenger compartment (see page 4, second column). The pattern is electronically altered for processing purposes and then applied to the pattern recognition apparatus to arrive at a determination of the occupying item, i.e., recognize and identify the occupying item. Based on the identification, the airbag may be disabled.

9. The CSOPD thus operates accordingly to a novel pattern recognition technique that is based on the fact that different objects will have different patterns of reflected waves or illumination. In other words, rear facing child seats will have one

general form of reflected waves or illumination whereas adult occupants will have another general form and a bag of groceries yet another general form.

10. The CSOPD disclosed in the SAE Paper forms the subject of the above-identified application.

11. Substantially all of the features set forth in the claims of the above-identified application are also described in the Paper.

12. In our opinion, the publication of this SAE Paper prior to April 12, 1994 conclusively demonstrates the conception of the claimed inventions prior to April 12, 1994 and acts supporting such conception occurred in the U.S.

13. After April 12, 1994 and prior to filing the parent application of the instant application on May 9, 1994, a draft patent application for this invention prepared by David S. Breed was being revised to conform to acceptable U.S. patent practice by the attorney handling matters on behalf of the assignee of the invention, Automotive Technologies International, Inc. As evidence of such work, attached hereto is a copy of the attorney's bill showing the hours spent on reviewing and revising the draft application. The parent application was designated docket no. ATI-77 and is also referred to by the initials VIMS-Vehicle Interior Monitoring System. As evidenced by the attached copy of the bill, on April 10-12, 1994, the attorney spent 1 hour on matters on behalf of the assignee (Automotive Technologies International (ATI)) including a review of the draft application for ATI-77 that was forwarded to him shortly before this date by Mr. Breed. Thereafter, the attorney spent 2.5 hours on ATI matters on April 17, 1994 including a review of ATI-77. Further, on April 24, 1994, the attorney spent 1 hour solely revising the draft application for ATI-77 including a telephonic discussion with Mr. Breed regarding the same. On April 26, 1994, the attorney spent an additional 2.75 hours revising the application and on April 27, 1994, an additional 1.75 hours.

14. After April 12, 1994 and prior to May 9, 1994, Mr. Breed was also preparing drawings for the application at his office in Boonton, Township, Morris County, New Jersey, U.S.A. As evidence of this work, submitted herewith is a printout of a list of the drawings prepared for this application indicating the date each drawing was <u>last modified</u>. It should be noted that FIG. 18 was last modified on April 22, 1994, FIGS. 1-6,

9 and 15 were last modified on April 29, 1994, FIGS 8, 11-14 and 16 were last modified on May 2, 1994 and FIGS. 10 and 19 were last modified on May 3, 1994. Thus, while the attorney was reviewing and revising the application, Mr. Breed was in the process of preparing drawings to file with the application.

15. After the attorney had completed revising the text of the application, a Declaration/Power of Attorney was sent to each of us for signature. Attached hereto are copies of the Declaration/Power of Attorney forms submitted with the parent application (ATI-77) showing a signature by the inventor Wendell C. Johnson on May 3, 1994 resident in Topanga, California and by the inventor Wilbur E. DuVall also on May 3, 1994 resident in Kimberling City, Missouri (but on a different document). Thus, these documents were sent to the respective inventor shortly before May 3, 1994 so that we were able to execute the Declarations on May 3, 1994 and thereafter return them to the attorney.

16. We hereby state that the above statements were made with the knowledge that willful false statements and the like are punishable by fine and/or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that any such willful false statement may jeopardize the validity of this application or any patent resulting therefrom.

Date: October 7, 1998 — Name: David S. Breed

Signature: [signature]

Date: October 14, 1998 — Name: Wilbur E. DuVall

Signature: Wilbur E. DuVall

Date: OCTOBER 15, 1998 — Name: Wendell C. Johnson

Signature: Wendell C. Johnson

DECLARATION FOR PATENT APPLICATION

Docket Number (Optional)
ATI 77

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled Vehicle Interior Identification and Monitoring System the specification of which

is attached hereto unless the following box is checked:

☐ was filed on ________ as United States Application Number or PCT International Application Number ________ and was amended on ________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status - patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

SAMUEL SHIPKOVITZ

Address all telephone calls to HIM at telephone number (703) 521-2345 ; (412) 521-3234

Address all correspondence to SAMUEL SHIPKOVITZ (5829 NICHOLSON, PGH., PA 15217)
MAILING ADDRESS: PO BOX 2961
ARLINGTON, VA 22202

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor (given name, family name) David S. Breed
Inventor's signature [signature] Date April 6, 1994
Residence 48 Hillcrest Rd. Citizenship U.S.A.
Post Office Address Boonton Township, NJ 07005

Full name of second joint inventor, if any (given name, family name) Wendell C. Johnson
Inventor's signature Date
Residence 860 Robinson Rd. Citizenship U.S.A.
Post Office Address Topanga, CA 90290

Full name of third joint inventor, if any (given name, family name) Wilbur E. Duvall
Inventor's signature Wilbur E. DuVall Date May 3, 1994
Residence 57 Northwoods Drive Citizenship U.S.A.
Post Office Address Kimberling, MO 65686

☐ Additional inventors are being named on separately numbered sheets attached hereto.

NOV 09 1998

DECLARATION FOR PATENT APPLICATION

Docket Number (Optional)
ATI 77

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled Vehicle Interior Identification and Monitoring System the specification of which

is attached hereto unless the following box is checked:
☐ was filed on __________ as United States Application Number or PCT International Application Number __________ and was amended on __________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).
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Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed
			☐ Yes ☐ No
			☐ Yes ☐ No
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(Application Serial No.)	(Filing Date)	(Status - patented, pending, abandoned)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor (given name, family name) David S. Breed
Inventor's signature __________ Date April 6, 1994
Residence 48 Hillcrest Rd. Citizenship U.S.A.
Post Office Address Boonton Township, NJ 07005

Full name of second joint inventor, if any (given name, family name) Wendell C. Johnson
Inventor's signature __________ Date 3 MAY 1994
Residence 860 Robinson Rd. Citizenship U.S.A.
Post Office Address Topanga, CA 90290

Full name of third joint inventor, if any (given name, family name) Wilbur E. Duvall
Inventor's signature __________ Date __________
Residence 57 Northwoods Drive Citizenship U.S.A.
Post Office Address Kimberling, MO 65686

☐ Additional inventors are being named on separately numbered sheets attached hereto

SAE TECHNICAL PAPER SERIES

940527

Vehicle Occupant Position Sensing

David S. Breed, Wilbur DuVall, and Vittorio Castelli
Automotive Technologies International, Inc.

The Engineering Society For Advancing Mobility Land Sea Air and Space®
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Vehicle Occupant Position Sensing

David S. Breed, Wilbur DuVall, and Vittorio Castelli
Automotive Technologies International, Inc.

ABSTRACT

Regardless of whether crash sensors are mounted in the crush zone or non-crush zone, there will always be crashes where the sensors trigger late and the occupant has moved to a position near to the airbag deployment cover where he or she may be injured by the deployment of the airbag. The required sensor triggering time is now determined by assuming that the occupant is a 50% male sitting in the mid seating position. 70% of vehicle occupants are smaller and, on average, sit closer to the airbag and thus are even more likely to be out-of-position. Finally, current sensor systems make no allowance for occupants that are wearing seatbelts, for rear facing child seats located on the front passenger seat or for unoccupied seats. There are thus strong safety reasons for occupant position sensors.

This paper discusses the above problems, the difficulties in sensing occupants and objects located in the vehicle and attempts to define the requirements for such devices. It also presents some of the added benefits which will result from effective sensors which can characterize the contents of the vehicle such as heating, air conditioning and entertainment systems which adjust to vehicle occupants.

THE MOTIVATIONS FOR PLACING an occupant presence and position sensor into an automobile are:

- A significant number of people are now injured by the deployment of the airbag itself and a smaller number are killed.
- A child in a rear facing child seat on the front seat is in danger if the passenger airbag deploys.
- If the passenger seat is unoccupied deployment of the passenger side airbag needlessly increases the cost to repair the vehicle.

Background

Crash sensors for determining that a vehicle is in a crash of sufficient magnitude as to require the deployment of an inflatable restraint system, or airbag, are either mounted in a portion of the front of the vehicle which has crushed by the time that sensor triggering is required, the crush zone, or elsewhere such as the passenger compartment, the non-crush zone. Regardless of where sensors are mounted there will always be crashes where the sensor triggers late and the occupant has moved to a position near to the airbag deployment cover. In such cases, the occupant may be seriously injured or even killed by the deployment of the airbag. The Occupant Position Sensor is largely concerned with preventing such injuries and deaths by preventing late airbag deployments.

In an SAE paper by Mertz, Driscoll, Lenox, Nyquist and Weber titled "Response of Animals Exposed to Deployment of Various Passenger Inflatable Restraint System Concepts for a Variety of Collision Severities and Animal Positions" (1), the authors show that an occupant can be killed or seriously injured by the airbag deployment if he or she is located out-of-position near or against the airbag when deployment is initiated. There are now many documented occurrences of such injuries and deaths in real world accidents.

All crush zone mounted sensors, in order to function properly, must be located in the crush zone at the required trigger time during a crash or they can trigger late (2). For the purposes here, the crush zone is defined as that portion of the vehicle which has crushed at the time that sensor triggering is required. In impacts with soft objects, the crush of a vehicle can be significantly less than for impacts with barriers for the same velocity change. In such cases, even at moderate velocity changes where an airbag might be of help in mitigating injuries, the crush zone mounted sensor might not actually be in the crush zone at the time that sensor triggering is required and trigger late. In these cases the occupant could become out-of-position when the sensor triggers and be injured or even killed by the deploying airbag.

There is a trend underway toward the implementation of Single Point Electronic sensors which are typically located in the passenger compartment. In theory, these sensors use sophisticated computer algorithms to determine that a particular crash is sufficiently severe as to require the deployment of an airbag. In a recent SAE paper (3), the authors argue that there is insufficient information in the non-crush zone of the vehicle to permit a decision to be made to deploy an airbag in time for many crashes. Thus, sensors mounted in the passenger compartment or other non-crush zone locations, will also trigger the deployment of the airbag late in many crashes and lead to deployment induced injuries.

The discussions of timely airbag deployment above are all based on the position of the average male (designated the 50% male) relative to the airbag or steering wheel. For the 50% male, the sensor triggering requirement is typically calculated based on an allowable motion of the occupant of 13 cm by the time that the airbag is fully inflated. Airbags typically require about 30 milliseconds of time to achieve full inflation and, therefore, the sensor must trigger inflation of the airbag 30 milliseconds before the occupant has moved forward 13 cm. The 50% male, however, is actually the 70% person, considering both males and females, and therefore about 70% of the population are smaller and sit, on average, closer to the airbag than the 50% male, and thus are exposed to a greater risk of interacting with the deploying airbag. A recent informal survey, for example, found that although the average male occupant sits about 30 cm from the steering wheel, about 2% of the population of drivers sit closer than 15 cm from the steering wheel and 10% sit closer than 25 cm. Also, about 1% of drivers sit at about 60 cm and about 16% sit at least 45 cm from the steering wheel. None of the sensor systems now on the market take into account of this variation in occupant seating position and yet this can have a critical effect on the sensor required triggering time.

For example, if a fully inflated driver side airbag is about 28 cm (11 inches) thick, measured from front to back, then any driver who is sitting closer than 28 cm will necessarily interact with the deploying airbag, and at some closer position such as 12 cm (5 inches), the airbag probably should not be deployed at all. These numbers depend, of course, on the particular vehicle and airbag design. For a recently analyzed 48 kph (30 mph) barrier crash of a mid-sized car, the sensor required triggering time in order to allow the airbag to inflate fully before the driver becomes closer than 12 cm from the steering wheel results in a maximum sensing time of 8 milliseconds for a driver initially positioned 18 cm (7 inches) from the airbag, 25 milliseconds at 25 cm, 45 milliseconds at 41 cm and 57 milliseconds for the occupant who is initially positioned at 56 cm from the airbag. Thus for the same crash, the sensor required triggering time varies from a no trigger situation to 57 milliseconds, depending on the initial position of the occupant. A single sensor triggering time criterion that fails to take this into account, therefore, will cause injuries to small people or deny the protection of the airbag to larger people. A very significant improvement to the performance of an airbag system will necessarily result from taking the occupant position into account as described herein.

A further complication results from the fact that a greater number of occupants are now wearing seatbelts which tends to prevent most of these occupants from getting too close to the airbag. Thus, just knowing the initial position of the occupant is insufficient and either the position and velocity must be continuously monitored or the use of the seatbelt must be known. Also, the driver may have fallen asleep or be unconscious prior to the crash, and be positioned against the steering wheel. Some sensor systems have been proposed that double integrate the acceleration pulse in the passenger compartment and determine the displacement of the occupant based on the calculated displacement of an unrestrained occupant seated at the mid-seating position. This sensor system then prevents the deployment of the airbag if, by this calculation, the occupant is too close to the airbag. This calculation can be greatly in error for the different seating positions discussed above and also for the seatbelted occupant, and thus an occupant who wears a seatbelt could be denied the added protection of the airbag in a severe crash.

As the number of vehicles which are equipped with airbags is now rapidly increasing, the incidence of late deployments is also increasing.

The OPS will be installed in the passenger compartment of an automotive vehicle equipped with an inflatable airbag. When the vehicle is subjected to a crash of sufficient magnitude as to require deployment of the airbag, and the sensor system has determined that the device is to be deployed, the OPS and associated electronic circuitry determines the position and velocity of the vehicle occupant relative to the airbag and disables deployment of the airbag if the occupant is positioned so that he is likely to be injured by the deploying airbag. Naturally, the addition of an occupant position sensor onto a vehicle leads to other possibilities as will be discussed below.

Thus far the use of the OPS to disable the airbag deployment has been discussed. Inflators now exist where the gas production rate can be controlled. If an occupant is already close enough to interact with the airbag but not so close that the deployment should be suppressed, a lesser inflation could help the occupant without injuring him. Since the OPS can determine where the occupant is, it can be used to control the inflation rate.

In each of the examples above, the position and velocity of the occupant is used to prevent or control the inflation of the airbag. In some cases the presence of an occupant, or of a rear facing child seat, can be used to control the deployment of the airbag. A child in a rear facing child seat can be injured if the airbag deploys and if the seat is unoccupied, there is no need to deploy the airbag. In these cases rather than the determination of the position of the occupant, the pattern of a rear facing child seat or of an occupant must be determined and differentiated from that of a forward facing child seat, a box or a bag of groceries. Thus two different technologies are required for the OPS, position and velocity determination and pattern recognition.

Timing Requirements for Position and Velocity Determination

As discussed above, if an occupant is positioned against the airbag when it deploys, he or she can be seriously injured or killed by the deployment itself. This can happen with small people who naturally sit close to the steering wheel even if they are wearing their seatbelts, or with larger people who have fallen asleep. It can also happen due to pre-crash braking or for a variety of other reasons. Also, all current crash sensor systems can trigger late in a crash after the occupant has already been forced against the airbag by the accident deceleration. This is particularly the case with new electronic single point sensors.

Several technologies exist which will permit a measurement to be made of the position and velocity of the occupant. These include laser optics, passive infrared, ultrasonics, optical focusing and radar. Of these, ultrasonics is the least expensive technology however it is slower than the radar and laser optics systems since it is limited by the velocity of sound. This limitation is not significant for determining the initial position of the occupant at the time of the start of the crash since the vehicle will not have changed its velocity and the occupant will therefore not have a significant velocity relative to the instrument panel.

The following analysis shows that an accurate determination can be made of the occupants relative velocity and thus whether or not to deploy the airbag even with the inherent delay caused by the time it takes for the signal to travel to the occupant and return.

The speed of sound in air is approximately 30 cm per millisecond (ms), so if the sonic transmitter and receiver are about 60 cm from the occupant, then the time from the transmission of a pulse until its reception is about four ms. This has two effects: at any time the latest distance measurement shows what the distance was at least two ms earlier and as much as six ms earlier, and the rate of distance measurements is limited to one per four ms. (The 60 cm distance should be an upper bound. Some occupants will be always closer, and others will move closer during the crash. The sonic pulses will be sent more rapidly as the occupant approaches the transceiver.)

These times can be significant only during a crash. For all other applications of the occupant position sensor (OPS), these sampling rates are more than adequate.

During a crash, the OPS would be used to disable the airbag deployment when the occupant is close enough to the airbag module that his/her interaction with the deploying airbag would cause serious injury. The driver-side airbag takes about 30 ms to deploy, and when it is fully deployed it extends about 28 cm from the steering wheel. A design criterion for the airbag system is that deployment should begin at least 30 ms before the average male driver is within 28 cm of the steering wheel. In many crashes though this criterion cannot be met for the actual driver, and not all interactions with the deploying airbag lead to serious injuries. Thus a specification for the OPS might be that the occupant not be allowed to hit the airbag when he/she is less than perhaps 10 cm from the steering wheel. This would balance the injury from the airbag against the injury from striking the steering wheel if the airbag were not there. Naturally, tests must be run to determine this number for a particular airbag system.

The time after the deployment signal is given until the airbag is 10 cm from the steering wheel will depend on the system, but may be about 10 to 12 ms. Therefore, the OPS must be able to predict where the driver will be 10 to 12 ms after the crash sensors have decided that the crash merits an airbag. With a sonic system this might require a 16 ms extrapolation from the latest data point. For a typical 48 kph barrier crash the deployment decision can be made at about 20 ms, and 10 to 12 ms after this an unrestrained driver has moved about 3 cm relative to the car. If the driver is then in the critical zone, then he/she would be only 13 cm from the steering wheel initially. The OPS has plenty of time to determine the initial position, and can disable the airbag system when the driver is initially less than 13 cm from the steering wheel.

For a lower speed barrier impact, or for a softer (longer duration) crash, the driver may have moved farther and have a higher relative velocity when the deployment decision is made. But this takes a longer time which means that more position samples are available. For example, in a 24 kph barrier crash the occupant has moved 5 cm at 50 ms. By 16 ms earlier 8 or 9 position data samples have been taken. The relative motion of an occupant, restrained or unrestrained, is quite smooth until the occupant strikes a hard object, and a sufficiently accurate extrapolation for 16 ms is easily possible with 8 sample points. If the occupant initially is farther from the steering wheel, then even more sample points are available before he/she approaches the critical zone.

Thus the turnaround time for the sonic pulse is not a serious problem for the foreseen applications of the occupant position sensor.

It should also be noted that using only the occupant position sensor is a worst case situation. Most airbag systems have an accelerometer which permits a determination of the relative velocity of the vehicle toward an unrestrained occupant. This additional information can be used to determine whether the occupant is being restrained by a seatbelt and to get even a more accurate extrapolation of his or her position forward in time.

Child Seat Detection and Pattern Recognition

The OPS market is now being driven more by the need to prevent deployment of the airbag when a rearfacing child seat is present then when an occupant is out-of-position. This becomes a problem of pattern recognition where the pattern of all "approved" child seats must be distinguished from an occupant. In the full implementation, the presence of an empty seat is also detected and the airbag deployment suppressed. There are many technologies which could potentially solve this problem and rather than discuss them in detail, a list of proposed tests for any candidate technology will be presented.

Here significant technical problems result from the various permitted actions of the passenger, which are unlikely for the driver, such as reading a newspaper or map while the vehicle is in motion.

In a similar manner that airbag crash sensors must

perform properly when subjected to a "library" of standard crashes (which may or may not represent the spectrum of real world crashes), a library of tests can be formed for the Child Seat and Occupant Presence Detectors (CSOPDs). Fortunately, the cost of conducting a test from such a library is inexpensive especially compared to the cost of a crash test which may approach $100,000. This permits the library to be quite large and also permits the use of technologies which may not be as easily understood as more conventional computer algorithms.

Before discussing particular tests in the CSOPD test library, a definition of what constitutes a pass or failure of a test is necessary. In most cases it is only necessary to detect a rear facing child seat or an empty seat once during a trip by a vehicle. It is unlikely, although not impossible, that once a rear facing child seat has been placed on the vehicle seat and the vehicle begins moving, that it will be moved from the front to the back of the vehicle. It is also unlikely that the vehicle will get into an accident requiring deployment of the airbag within the first minute or so of the trip. Therefore there is plenty of time for the CSOPD to detect that a rear facing child seat is present and once it has made that decision it need not change unless the evidence is strong that the child seat is no longer present. For the CSOPD to pass a particular test, therefore, it should be permitted at least a minute to reach a decision and it should not change its decision unless the test condition has changed requiring such a decision change.

As with airbag crash sensors, the test library applies to each model vehicle on which the CSOPD is to be used unless it can be shown that the technology is not influenced by the vehicle.

Rear Facing Child Seat Presence Tests

Each test should be performed for each "approved" child and infant seat. The technology should recognize the presence of a rear facing child seat regardless of: the position of the child seat on the vehicle seat; the position of the vehicle seat; whether the child seat is belted or not; the angular orientation (yaw) of the child seat as long as it is facing substantially rear; the front to back angular orientation (pitch) of the child seat; and, the presence of blankets, dolls, toys or other objects on the child seat. The number of such tests will depend on the nature of the technology used for the CSOPD.

Forward Facing Child Seat Presence Tests

Tests similar to those discussed above should be repeated with the child seat facing forward to demonstrate that the airbag is not disabled.

Occupant Presence Tests

A variety of occupants should be used which represent the extremes as well as the norm of the human population. Once again the particular choice of tests will depend on the particular CSOPD technology used. For this series of tests, the object is to see if the CSOPD can be fooled into thinking that the occupant is a rear facing child seat or that the seat is empty. Occupants should read newspapers, lie down on the seat, sit very near to the driver, wear heavy bulky clothing, hats or anything else which might fool the system.

Empty Seat Tests

A series of tests using packages, bags of groceries, etc., should be conducted to demonstrate that such objects are not misinterpreted as a child seat or an occupant. If the CSOPD fails a test in this series, the consequences are not serious since it will fail to suppress the airbag in the event of an accident. If this were a common occurrence, however, the customers or their insurance companies, might become annoyed.

Other Tests

Finally, a series of tests using animals, for example, and any other situations which might defeat the CSOPD technology should be identified based on an understanding of the particular technology. If ultrasonics are used, for example, the effects of wind noise or any other sources of noise, either ultrasonic or audible, should be investigated.

Automobile manufacturers are now concerned that they must tell customers that the child seats must be on the rear seat of the vehicle. They are even more concerned about the situation in trucks, one of the fastest growing markets, where there is no rear seat. The OPS market is now being driven by the desire to prevent the deployment of the passenger side airbag if a rear facing child seat is present on the front passenger seat.

Technology Comparisons

The following is a brief review of available technologies.

Passive infrared

In this system, the CSOPD responds to the temperature of the occupant which can either be a child in a rear facing child seat or an occupant. The sensing of the child could pose a problem if the child is covered with blankets. It also might not be possible to differentiate between a rear facing and forward facing child seat. In all cases, the technology will fail to detect the occupant if the ambient temperature reaches body temperature as it does in hot climates.

Laser Optical

In this system a laser beam is momentarily used to illuminate an occupant or child seat. Many variations of the technology are possible such as using a charge coupled device (a type of TV camera), a scanning system, or a cone of light which covers a large portion of the object coupled with a pattern recognition system. This and the radar system can provide the most information about the object and at a rapid data rate. Their main drawback is their cost which is considerably above that of ultrasonic systems. As the cost of lasers comes down in the future, this system will become more competitive. Depending on the implementation of the system, there may be some concern for the safety of the occupant if the laser light can enter the occupants eyes.

Radar

This system has similar properties to the laser system discussed above. Once again there is some concern about the health effects of radar on children and other occupants.

Ultrasonic

This is the least expensive system and potentially provides less information than the laser or radar systems due to the delays experienced resulting from the speed of sound and due to the wave length which is considerably longer than the laser or radar systems and which limits the detail which can be seen by the system. In spite of these limitations, as shown above, ultrasonics can provide sufficient timely information to permit the position and velocity of the occupant to be accurately known. The use of ultrasonics to determine the presence of a rear facing child seat has also been demonstrated.

Focusing

Focusing systems, such as used in some camera systems, could be used to determine the initial position of an occupant but would be too slow to monitor his position during a crash. Also by itself it cannot determine the presence of a rear facing child seat or of an occupant.

Conclusions

With the expected installation of side impact airbags, which will be initially stored in the doors of the vehicle, the potential for deployment induced injuries will increase significantly. The head of a small child, for example, may be adjacent to the deployment door of such an airbag especially if he is sleeping against the door. Therefore the CSOPD will eventually be needed for side impact airbags. Some manufacturers are now experimenting with rear seat airbags. As the number of airbags in a vehicle increases, the need for occupant presence detection, and for rear facing child seat detection, also increases. It would not be tolerable to deploy multiple airbags in a frontal or side impact, for example, if the vehicle has only one occupant.

Once a CSOPD is present in a vehicle, other possibilities suggest themselves such as the monitoring of the driver's behavior which can be used to warn a driver if he or she is falling asleep, or to stop the vehicle if the driver loses the capacity to control it. Additionally, a mapping of the vehicle occupants can be used to adjust the heating, air conditioning or sound in the vehicle. Finally, in the case of an accident, the information as to the number of occupants can be transmitted automatically using the vehicle's cellular phone to call for help and order the requisite number of ambulances. Perhaps a more advanced system will someday be used to recognize the driver, automatically adjust the seat, mirrors etc. and even control who is permitted to operate the vehicle!

References

1. Mertz, Driscoll, Lenox, Nyquist and Weber titled "Response of Animals Exposed to Deployment of Various Passenger Inflatable Restraint System Concepts for a Variety of Collision Severities and Animal Positions" SAE 826074, 1982

2. Breed, D.S., Castelli, V. "Trends in Sensing Frontal Impacts", Society of Automotive Engineers No. 890750, 1989.

3. Breed, D.S., Sanders, W.T. and Castelli, V. "A Critique of Single Point Crash Sensing", Society of Automotive Engineers No. 920124, 1992.

Figures

Name	Size	Kind	Last Modified	
ATI 77 FIG. 1	7K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:48 PM
ATI 77 FIG. 2	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:46 PM
ATI 77 FIG. 3	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:52 PM
ATI 77 FIG. 4	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	3:57 PM
ATI 77 FIG. 5	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:00 PM
ATI 77 FIG. 6	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:04 PM
ATI 77 FIG. 7A	7K	MacDraft 1.3 doc...	Tue, Apr 5, 1994	5:09 PM
ATI 77 FIG. 7B	7K	MacDraft 1.3 doc...	Tue, Apr 5, 1994	5:10 PM
ATI 77 FIG. 8	7K	MacDraft 1.3 doc...	Mon, May 2, 1994	10:39 AM
ATI 77 FIG. 9	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:16 PM
ATI 77 FIG. 10	13K	MacDraft 1.3 doc...	Tue, May 3, 1994	4:29 PM
ATI 77 FIG. 10.1	7K	MacDraft 1.3 doc...	Mon, May 2, 1994	2:33 PM
ATI 77 FIG. 11	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:09 AM
ATI 77 FIG. 12	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:18 AM
ATI 77 FIG. 13	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:21 AM
ATI 77 FIG. 14	7K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:37 AM
ATI 77 FIG. 15	13K	MacDraft 1.3 doc...	Fri, Apr 29, 1994	4:54 PM
ATI 77 FIG. 16	13K	MacDraft 1.3 doc...	Mon, May 2, 1994	11:59 AM
ATI 77 FIG. 17	13K	MacDraft 1.3 doc...	Mon, Apr 4, 1994	4:07 PM
ATI 77 FIG. 18	13K	MacDraft 1.3 doc...	Fri, Apr 22, 1994	4:15 PM
ATI 77 FIG. 18.1	13K	MacDraft 1.3 doc...	Tue, May 3, 1994	4:28 PM
ATI 77 FIG. 19	13K	MacDraft 1.3 doc...	Tue, May 3, 1994	4:38 PM

STATEMENT 47572

Date APRIL 29 1994

TO Dr David Breed
AUTOMOTIVE TECHNOLOGIES INT'L, INC.
P.O. Box 1028
Denville, N.J. 07834

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APR 24	ATI 77 V/MS 1.0 phone DBreed est	8	00
APR 25	ATI 77 ATI 68 1.0 1.0		
APR 26	ATI 77 2.75		
APR 27	V/MS 1.75		
	Faxed 6pp 305/534 2405 day ATI 39	9	00
APR 28	ATI 38.1-24 Request 1.0		
APR 29	update search computer .4 hr		52
	ATI 38.1-24 Response 2.5 hr		
	rec'd 20pp FAX	7	00
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STATEMENT 47570.

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MAR 11	mailed 2 copies of ATI 39 originals to DB	20	00	
		2	90	
MARCH 16	review of ATI 33.1/33 3 hrs			
MARCH 17	disc re: foreign filings to be made by others NOT me KFM, M Foyel 1 hr			
MAR 25 / MARCH 28	disc re: foreign filings to be made by others not me .5 hr			
	phone calls + FAX Mr Foycik letter 6 pp	9	50	
MAR 24-25	disc w/ Mike Foycik, Esq re: foreign filing .5 hr			
Mar 28	disc w/ Mike Foycik, Esq re: PCT Request .5 hr			
Mar 29	disc w/ DB re: KFM .1 hr			
Mar 31	FAX ATI 39 Petre: order of names granted; FAX ATI 38.1 Restriction Request 1 Mo. letter			.1 hr
APR 10-12	ATI 77 review ATI 68 review / disc w DB	2	00	1.0 hr
APR 11-12	ATI 33.1 prog A 5.0 hrs est phone	3	50	
APR 13	ATI 33.1 prog A 3.5 hrs est phone	3	00	
APR 14	ATI 33.1 prog A 2.5 hrs est phone	3	00	
APR 15	ATI 33.1 prog A / copies DB call to DB est	4	00	6.0 hrs
Apr 16	ATI 33.1 Amendment 2.7 hrs			
Apr 17	phone calls/FAXing est	8	80	
Apr 17	hotel call to DDA est	4	50	.1 hr
	ATI 77 VID&MS review DB			2.5 hrs
	ATI 68 Fuel Tank			

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